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Bacteriological Quality and Risk Factors for Contamination of Raw Mixed Vegetable Salads Served in Collective Catering in Abidjan (Ivory Coast)

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Abstract

The aim of this study was to determine the bacteriological quality of raw mixed vegetable salads served in collective catering in Abidjan and to assess the factors likely to favor contamination. An investigation was conducted to determine the practical risk of contamination. A total of 306 samples were collected and analyzed for the detection and enumeration of *Enterobacteriaceae*, *E. coli* and *Salmonella* according to standard microbiology methods. The most important risk factors were lack of training (96.7%), decontamination (84.0%), cross-contamination of vegetables in contact with fresh chicken or fish (76.7%) and salads that were uncovered and unprotected, thus exposed to the air and at ambient temperature for sale (97.7%). Theprevalence was 100%, 77.8% and 2.6% respectively for *Enterobacteriaceae*, *E. coli* and *Salmonella.* The average load of *Enterobacteriaceae* and *E. coli* was 4.93 $\log_{10}$ (CFU/g) and 1.89 $\log_{10}$ (CFU/g), respectively. Unsatisfactory microbiological quality samples were 52.3%. The results showed a failure of the sanitary quality in more than half of the products. Raising awareness in all of the workers in the food chain for vegetable salads is thus necessary to protect the health of the consumers.

Keywords

Vegetable Salads, *E. coli*, *Salmonella*, Risk Factors, Collective Catering

1. Introduction

Fruits and vegetables are an essential part of the human diet. A diet rich in fruits

and vegetables reduces the risk of obesity, cancers and cardiovascular diseases that are considered to be the leading causes of death and disability in the world [1] [2]). Thus, World Health Organization (WHO), European Food Safety Authority (EFSA), Food & Agriculture Organization (FAO) and French Agency for Food Safety (AFSSA) recommend and encourage consumption of at least five servings of fruits and vegetables per day [2]. Despite the benefits that are associated with consumption of fruits and vegetables, food security of those consumed fresh remains a major concern, because these foods are considered as vectors of infectious disease transmission [3].

Over past decade, the number of cases of foodborne illness associated with fresh fruits and vegetables in developed countries has increased. Among the pathogens, pathogenic *E. coli* and *Salmonella* are most often involved [4] [5] [6] [7]. From May to June 2011, two separate outbreaks of bloody diarrhea and hemolytic uremic syndrome (HUS) occurred in Europe and both were caused by shiga toxin producing a strain (STEC) O104:H4. An outbreak centered in Germany included 845 cases of HUS and 54 deaths; the other outbreak, centered in France, included only nine cases of HUS [6] [8]. This was one of the largest outbreaks of poisoning in Shiga Toxin *E. coli* (STEC) associated with vegetables, and was never reported. In developing countries, foodborne illnesses caused by contaminated fruits and vegetables are common and, in some areas, they cause a high proportion of diseases; however, due to the lack of investigation and monitoring of foodborne diseases in most of these countries, a very high proportion of outbreaks are not detected, or very few are mentioned in scientific reports [3]. Vegetable contamination can occur at any time in the food chain, from the farms to the consumer's plate, through transportation, distribution and markets, with the presence or absence of pathogens [9]. In developing countries, many risk factors are considered the main contamination factors, such as improperly composted manure, untreated wastewater used for irrigation, poor post-harvest handling, especially in markets, and unhygienic food handling practices [10] [11] [12].

In Côte d'Ivoire, raw mixed vegetable salads are generally made of raw tomatoes, onions, cucumbers and/or lettuce that have been washed, peeled, cut, seasoned or unseasoned and ready to use. They are used in catering as a garnish or accompaniment to many meals. Studies have shown that vegetables are subjected to various sources of microbial contamination before and after harvesting, during transport and at places of sale in Abidjan [13] [14] [15]. Microorganisms, mainly enteric bacteria with pathogenic potentialities, including *Salmonella* and *E. coli*, were isolated from vegetables harvested in fields and sold in markets [14]. There is a lack of data available on the microbiological quality of lettuce in the fields and markets; there is none for raw mixed vegetable salads served in catering. Furthermore, there is a lack of data on key risk factors for contamination of salads.

The aim of this study is to assess the bacteriological quality and to determine risk factors for contamination with enteric bacteria including *E. coli* and *Salmo-*

nella in raw mixed vegetable salads served in catering to Abidjan.

2. Materials and Methods

2.1. Study Areas

The study was conducted in the district of Abidjan, the economic capital of Côte d'Ivoire. The district is located in the south, bordering the Atlantic Ocean (Gulf of Guinea), covering an area of 2119 km^2 (0.6% of the country) with a population density of 1475 inhabitants/km^2. According to the *Institut National de la Statistique de Côte d'Ivoire* (INS), the district of Abidjan has an estimated population of 4,707,000 inhabitants; representing 20.7% of the total population and a growth rate of 3.7% per year [16]. Abidjan is a large area of agricultural production, especially of vegetables, and where one meets different sites of restoration. The city comprises 13 municipalities, including five where this study was conducted. **Figure 1** shows a map of the city with the study sites indicated.

2.2. Investigation

A survey based on questionnaires and direct observation was conducted from March to November 2015 among 150 vendors of raw vegetable salads that were used as an accompaniment to main meal in catering in Abidjan. To validate this questionnaire, a focus group of five randomly selected individuals was constituted. Sociodemographic characteristics (age, nationality, education level, years of experience, catering training) and risk factors that could cause contamination of vegetables were determined. These included: conditions for the preservation of vegetables in the restaurant, methods and products used for washing and decontamination of vegetables, utensils used for cutting and dressing and the possibility of cross-contamination with fresh meat products (meat, poultry, fish).

2.3. Sampling of Raw Mixed Vegetables Salads

A total of 306 samples of raw mixed vegetable salads, consisting of tomatoes, onions, cucumbers and/or lettuce, seasoned or unseasoned, were collected for analysis. In each restaurant, two samples of about 100 to 200 g were collected at two-week intervals. Samples were collected between 7 am and 5 pm and between 6 pm and 11 pm, depending on the main course that accompanied the salad. A file was attached to each sample for information on the type of vegetables added in the salad preparation, the time of sampling (day or night) and the sampling commune (Abobo, Adjamé, Yopougon, Treichville, Cocody). After collection, the samples were transported to the laboratory in a cooler containing Ice-Pack.

2.4. Analysis of Samples

From each sample previously ground in a Stomatcher (Seward Limited, England), 25 grams were weighed aseptically and added to 225 ml buffered peptone water (Bio-rad, France) for the preparation of initial suspensions. Serial dilutions (10-1 to 10-5) were carried out in tryptone salt (Biorad, France). Initial suspensions and dilutions were used for the culture and enumeration of *Enterobacte-*

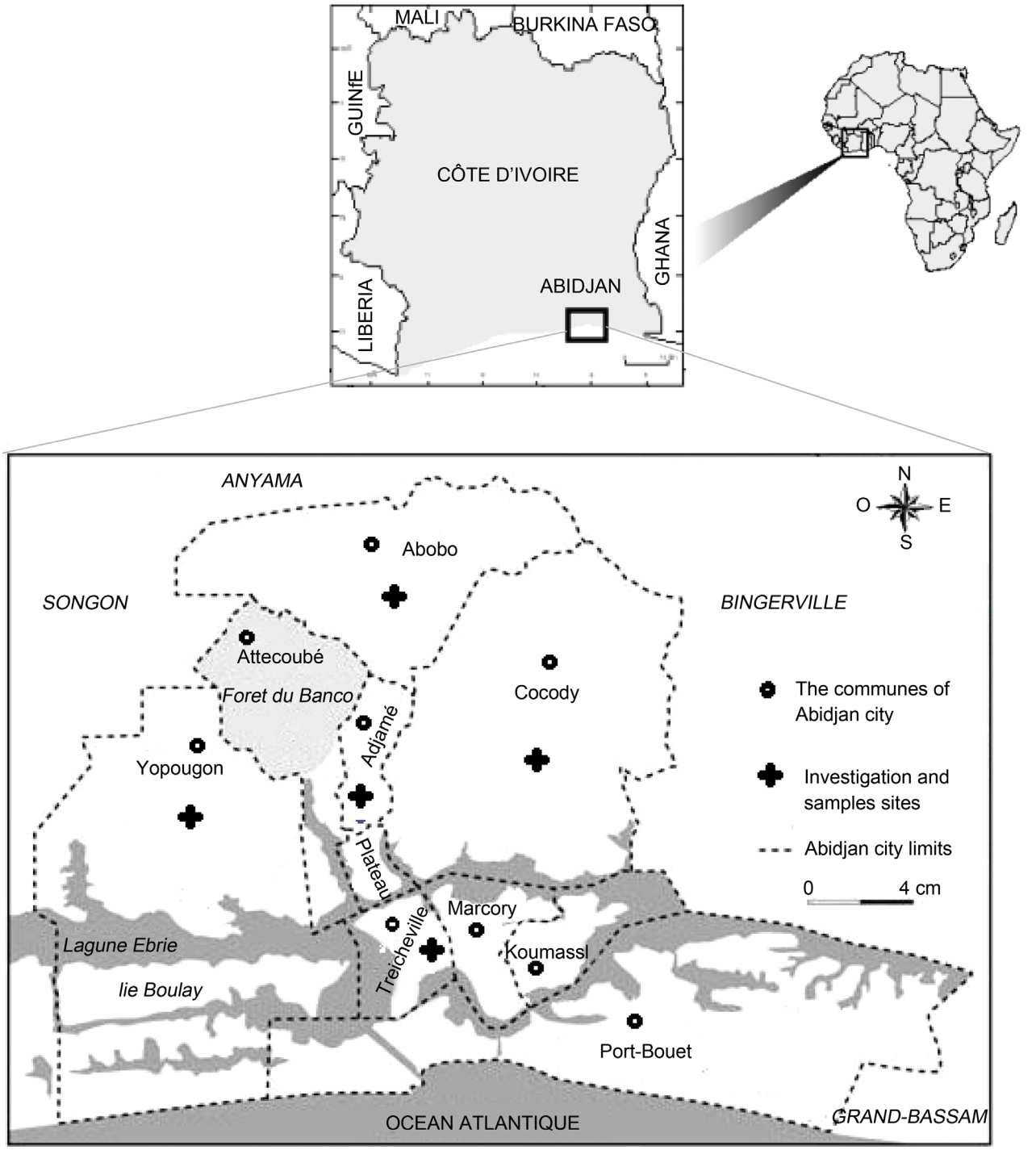

Figure 1. Map of Abidjan with the study sites indicated.

riaceae, *E. coli*, and the search for *salmonella*, in order to investigate two factors, including bacterial loads and non-selective pre-enrichment in the case of *Salmonella*.

2.4.1. Enumeration of Enterobacteriaceae

Enumeration of *Enterobacteriaceae* was made according to ISO 21528-2:2004. A culture was performed on agar VRBG (Violet Red Bile Glucose Agar) (Bio-Rad,

France). After incubation at 37˚C for 24 hours, the characteristic red violet colonies with a diameter of 0.5 mm or more, sometimes surrounded by a reddish zone, were counted.

2.4.2. Enumeration of *E. coli*

The enumeration of *E. coli* was performed on selective chromogenic medium RAPID' *E. coli* 2 (Bio-Rad, France), according to ISO 16140. After incubation at 44˚C for 24 hours, colonies of *E. coli*, which are purple to pink due to the presence of β-D-glucuronidase (GLUC) and β-D-galactosidase (GAL), were counted.

2.4.3. Detection of *Salmonella*

The detection of *Salmonella* was carried out according to standard NF EN ISO 6579: 2002. Each initial suspension was incubated at 37˚C for 18 hours for pre-enrichment. After incubation, 0.1 ml of this suspension was added to 10 ml of RVS broth (Bio-rad, France); in parallel, a series of two drops was deposited at the center of two petri dishes containing a Medium Semisolid Rappaport Vassiliadis (MSRV) supplemented with novobiocin 20 mg/l (Lyofilichen, France). The RVS and MSRV broths (Bio-rad, France) were incubated at 42˚C. for 24 hours for the first, and 24 to 48 hours for the second. Both media were then seeded on Hektoen (Bio-rad, France) and *Salmonella-Shigella* (SS) agar plates and incubated at 37˚C. for 24 hours. On SS agar, *Salmonella* have colorless and transparent colonies (due to lactose fermentation), with or without a black center (H_2S production) and on Hektoen, from blue to green colonies with or without a black center. Five characteristic colonies on each plate were streaked on nutrient agar for biochemical identification. Biochemical identification was performed using an API 20E gallery.

2.5. Statistical Analysis and Interpretations of Results

The results of the surveys were coded and entered in Microsoft Excel version 2013 and transferred to IBM SPSS VERSION 20. Descriptive statistics (frequency, mean, standard deviation) were used for the quantitative variables. Data on socio-demographic characteristics (age, sex, nationality, religion, level of education, experience) and data on microbiological analysis (frequency, average loads, compliance) were analyzed for variance (Anova), with a factor to determine the relationship between dependent and independent (common) variables. A post-hoc comparison test with Bonferroni was performed when there were differences between the variables. The differences between the variables were considered significant at $p < 0.05$. All statistical analyzes were performed using SPSS statistical program for Windows version 20. For the enumeration, the boxes containing less than 150 colonies and medium loads were taken into account and have been reported according to ISO 7218_2007, and then transformed into $\log_{10}$ CFU/g. The standard used by the French Association of Standardization (AFNOR), which indicates a limit of 10^2 CFU/g ($2\log_{10}$ CFU/g) for *E. coli* for ready-to-eat foods, and the absence in 25 g in the case of *Salmonella.* The use of these limits made it possible to assess the microbiological quality and/or the conformity of

the samples analyzed.

3. Results

3.1. Sociodemographic Characteristics

Sociodemographic characteristics have been analyzed to highlight the impact of the following factors: education level and the training in catering on food microbiological quality. In catering, where raw mixed vegetable salads are used, accompanied by the main course, all interviewed sellers were only women vendors, whose ages varied between 30 and 45 years, and represented 54%.The vast majority never followed catering training (96.7%), and had been practicing this activity for more than five years (40.7%). Of these women, 31.3% had a primary education level and 41.3% had never attended school. From one commune to another, sociodemographic characteristics did not vary significantly ($P > 0.05$) outside age, level of study and number of years of experience ($P < 0.05$) (Table 1).

3.2. Factors and Practices at Risk of Contamination

After buying at the market, 96.3% of salespeople store vegetables at the point of sale and 72.5% at room temperature without protection. During the conservation, vegetables come into contact with food of animal origin in 23.3% of cases. Before cutting up the vegetables, sellers say they do not wash (1.3%) and disinfect them (84%). At the point of sale, 22% say they do not change the rinse water

Table 1. Sociodemographic characteristics of vegetable salad vendors.

Parameters	Responses	Respondents (%)					Total N:
		Adjamé N:30	Abobo N:30	Yop N:30	Cocody N:30	Treic N:30	
Sex	Man	0a	0a	0a	0a	0a	0.0
	Woman	100a	100a	100a	100a	100a	100.0
Origin	Ivorian	90.0a	86.7a	83.3a	80.0a	93.3a	86.7a
	Not Ivorian	10.0a	13.3a	16.7a	20.0a	6.7a	13,3a
Age	Under 30 years	43.3a	43.3ab	33.3a	16.7ab	10.0b	29.3
	30 - 45 years	46.7a	50.0a	63.3a	43.3a	66.7b	54.0
	Over 45 years	10.0abcd	6.7bd	3.3cd	40.0a	23.3abcd	16.7
Studylevel	Not in school	56.7a	40.0a	33.3a	36.7a	40.0a	41.3b
	Primaryschool	26.7a	36.7a	23.3a	26.7a	43.3a	31.3c
	Secondaryschool	16.7a	13.3a	40.0a	26.7a	13.3a	22.0
	High school	0.0a	10.0a	3.3a	10.0a	3.3a	5.3
Training in catering	No	100a	93.3a	100a	93.7a	96.7a	96.7
	Yes	0.0a	6.7a	0.0a	6.7a	3.3a	3.3
Years of experience	Under 5 years	50.0a	50.0a	40.0a	23.3a	40.0a	40.7a
	5 - 15 years	40.0a	33.3a	46.7a	50.0a	16.7a	37.3b
	Over 15 years	10.0a	16.7ab	13.3ab	26.7ab	43.3b	22.0

Note: Means with the same letter in the same column are not significantly different ($P < 0.05$). Commun: Yop (Yopougon) and Treich (Treicheville).

during the cutting and 38.7% say they entrust the cutting up of the vegetables to the younger girls. Vegetables are cut up and progressively used during the hours of sale in 64.4% of the cases and stored at room temperature in 97.7% of the cases. The utensils used to cut vegetables are also used to cut chicken or fresh fish (37.7%). Special containers are used for seasoning the vegetables cut in most cases (79.3%) and are not cleaned during sale in 47.8% of cases (Table 2).

3.3. Prevalence of Bacteria in Vegetable Salad Samples

The prevalences of bacteria in the analyzed samples are presented in Table 3. The prevalences are 100%, 77.8% and 2.6% respectively for *Enterobacteriaceae*, *E. coli* and *Salmonella* and are significantly different ($P < 0.05$). Prevalences of *E.*

Table 2. Sales conditions and practices.

Parameters	Responses	Respondents (%)					Total
		Adj	Abobo	Yop	Cocody	Treich	
Methods of preserving vegetables	Refrigerator	3.3a	0.0a	3.3a	10a	0.0a	3.3
	ambiant T	96.7a	100a	96.7a	90.0b	100a	96.7
Protection vegetables at room temperature	No	70.0a	58.6a	80.0a	76.7a	76.7a	72.5a
	Yes	30.0a	41.4	20.0a	23.3a	23.3a	27.5a
Contact with chicken or fish in storage	No	86.7a	80.0a	40.0b	83.3a	93.3a	76.7
	Yes	13.3a	20.0a	60.0b	16.7a	6.7a	23.3
Washed before cutting	No	3.3a	0a	3.3a	0a	0a	98.7
	Yes	96.7a	100a	96.7a	100a	100a	1.3
Disinfection of vegetables before cutting	No	86.7a	90.0a	86.7a	66.7a	90.0a	84.0a
	Yes	13.3a	10.0a	13.3a	33.3a	10.0a	16.0
Change of the rinse water during the cutting	No	40.0a	6.7b	3.3b	16.7ab	43.3a	22.0
	Yes	60.0a	93.3b	96.7a	83.3ab	56.7a	78.0
Personnel responsible for cutting vegetables	Vendors	36.7a	73.3b	60.0ab	66.7ab	70.0ab	61.3
	Young Girls	63.3a	26.7b	40.0ab	33.3ab	30.0ab	38.7
Immediate use of cut vegetables	Yes	6.7a	66.7c	20.0ab	40.0bc	46.7bc	36.0
	No	93.3a	33.3c	80.0ab	60.0bc	53.3c	64.0
Mode of salads conservation	Refrigerator	0a	0a	0a	8.3	0a	2.3
	Ambient T	100a	100a	100a	91.7	100a	97.7
Using the same utensil for cutting vegetables, chicken or fresh fish	No	20.0ab	53.3ac	10.0b	40.0abc	63.3c	37.3
	Yes	80.0ab	46.7ac	90.0b	60.0abc	36.7c	62.7
Washing the container during the sale	No	94.4a	14.8b	25.9b	46.7b	100a	47.8
	Yes	5.6a	85.2b	74.1b	53.3b	0a	52.2
Means used for serving salads	Bare Hands	0.0a	10.3a	6.7a	3.3a	20.8	8.0
	Protected Hands	0.0a	3.4a	10.0a	16.7a	0.0a	6.5
	Spoon/Ladle	100a	86.2a	83.3a	80.0a	79.2a	85.5

Note: Means with the same letter in the same column are not significantly different. ($P < 0.05$). Commun: Yop (Yopougon) and Treich (Treicheville).

Table 3. Prevalence of bacteria in vegetable salad samples.

Sampling parameters	Categories	N	Prevalence of bacteria (%)		
			Enterobacteriaceae	*E. coli*	*Salmonella*
Types of vegetables constituting the salad	To + On	184	100a	63.6a	0.5a
	To + On + Cu	108	100a	99.1b	5.6b
	To + On + Cu + Lt	14	100a	100b	7.1ab
	TOTAL	**306**	**100**	**77.8**	**2.6**
Salads sampling time	Day	172	100a	66.9a	0.6a
	Night	132	100a	91.8b	5.2b
	TOTAL	**306**	**100**	**77.8**	**2.6**
Communes of sampling salad	Abobo	60	100a	81.7a	5.0a
	Adjamé	64	100a	78.1a	3.1a
	Treichville	60	100a	78.3a	3.2a
	Yopougon	62	100a	75.8a	1.7a
	Cocody	60	100a	75.0a	0.0a
	TOTAL	**306**	**100**	**77.8**	**2.6**

Note: Means with the same letter in the same line are not significantly different ($P < 0.05$). To: tomatoes; On: onion; Cu: cucumbers; Lt: Lettuce.

coli and *Salmonella* did not vary significantly in vegetable salads collected from one commune to another ($P > 0.05$); on the other hand, they varied considerably according to the sampling time and the type of vegetables making up the vegetable salads ($P < 0.05$). Salads collected at night and salads that contained tomato, onion, cucumber and lettuce showed significantly higher prevalence in *E. coli* and *Salmonella* ($P < 0.05$).

3.4. Average Bacterial Loads in Vegetable Salad Samples

Mean loads of bacteria in the analyzed samples are presented in Table 4. The mean loads were 4.9 ± 1.1 and 1.9 ± 1.3 Log_{10} CFU/g for *Enterobacteriaceae* and *E. coli* respectively and were significantly Different ($P < 0.05$). Mean loads of *E. coli* did not vary significantly in samples of vegetable salads taken from one commune to another, unlike those of *Enterobacteriaceae*. Both varied significantly according the sampling time and type of vegetables comprising the vegetable salad ($P < 0.05$). Salads collected at night and salads containing tomato, onion, cucumber and lettuce showed significantly higher mean *E. coli* loads ($P < 0.05$).

3.5. Microbiological Quality of Vegetable Salads

The percentages of unsatisfactory microbiological quality samples are respectively 52.3% related to *E. coli* and 2.6% for *Salmonella.* Percentages of vegetable salads of unsatisfactory microbiological quality did not vary significantly from samples from one commune to another ($P > 0.05$), but varied significantly according the time of sampling and types of vegetables that made up the salads ($P < 0.05$). The salads collected at night and salads that contained tomato, onion,

Table 4. Microbiological quality of samples.

Sampling parameters	Categories	N	Mean load of bacteria (Log_{10} CFU/g)	
			Enterobacteriaceae	*E. coli*
Types of vegetables constituting the salad	To + On	184	4.86 ± 1.1a	1.46 ± 1.3a
	To + On + Cu	108	4.97 ± 1.0b	2.54 ± 1.0b
	To + On + Cu + Lt	14	5.58 ± 0.9b	2.61 ± 0.4b
	TOTAL	**306**	**4.9 ± 1.11**	**1.89 ± 1.2**
Salads sampling time	Day	172	5.1 ± 1.1a	1.51 ± 1.31a
	Night	132	4.7 ± 1.0b	2.39 ± 1.09b
	TOTAL	**306**	**4.9 ± 1.1**	**1.9 ± 1.3**
Communes of sampling salad	Abobo	60	5.2 ± 0.8a	2.2 ± 1.40a
	Adjamé	64	5.2 ± 1.2a	1.98 ± 1.3a
	Treichville	60	5.0 ± 1.0a	1.85 ± 1.2a
	Yopougon	62	4.9 ± 1.1a	1.8 ± 1.3a
	Cocody	60	4.3 ± 1.2b	1.7 ± 1.1a
	TOTAL	**306**	**4.9 ± 1.1a**	**1.9 ± 1.3a**

Note: Means with the same letter in the same line are not significantly different ($P < 0.05$). To: tomatoes; On: onion; Cu: cucumbers; Lt: Lettuce.

cucumber and lettuce presented the most significantly elevated percentages of unsatisfactory microbiological quality ($P < 0.05$) for *Salmonella* and *E. coli* (Table 5).

4. Discussion

The absence of school-level education and training in catering for the majority of vendors are factors that may influence their ignorance of the impact of good handling practices on the quality of food for human consumption [17]. This may explain the lack of precaution, good hygiene practices and proper handling to avoid contamination. According to FAO [18], catering operations posed particular risks (foodborne diseases) because of the way the food is stored and handled. For this purpose, food handlers should be trained in food safety and personal hygiene in order to be aware of the precautions that need to be taken to avoid any form of contamination.

Contamination due to lack of precautions, good handling practices and hygiene measures were observed during the preparation of vegetable salads. It was found that there was absence of effective decontamination of vegetables in order to eliminate or reduce the initial contaminants, the vegetable cutting stage being entrusted to young girls was not always hygienic and the contact of vegetables with foods (chicken, fish, etc.) or utensils that had been in contact with these foods. Contamination was also observed by the preservation of vegetable salads at room temperature during the sale and using bare hands to serve the salads. These factors have already been cited and involved in cases of food contamination in other countries [9] [10] [12] [19] [20] [21] [22].

Table 5. Microbiological quality of samples.

Sampling parameters	Categories	N	Microbiological quality of samples (%)				
			E. coli			*Salmonella*	
			S	*Ac*	*NS*	*S*	*C*
Types of vegetables constituting the salad	To + On	184	36.4a	24.5a	39.1a	99.5a	0.5a
	To + On + Cu	108	0.9b	29.6a	69.4b	94.4b	5.6b
	To + On + Cu + Lt	14	0.0b	7.1b	92.9b	92.9ab	7.1ab
	TOTAL	**306**	**22.2**	**25.5**	**52.3**	**97.4**	**2.6**
Salads sampling time	Day	172	33.1a	28.5a	38.4a	99.4a	0.6a
	Night	132	8.2b	21.6a	70.1b	94.8b	5.2b
	TOTAL	**306**	**22.2**	**25.5**	**52.3**	**97.4**	**2.6**
Communes of sampling salad	Abobo	60	18.3a	21.7a	60.0a	95.0a	5.0a
	Adjamé	64	21.9a	26.6a	51.6a	96.9a	3.1a
	Treichville	60	21.7a	28.3	50.0a	98.3a	1.7a
	Yopougon	62	24.2a	24.2a	51.6a	96.8a	3.2a
	Cocody	60	25.0a	26.7a	48.3a	100.0a	0.0a
	TOTAL	**306**	**22.2**	**25.5**	**52.3**	**97.4**	**2.6**

Note: Means with the same letter in the same line are not significantly different ($P < 0.05$).; To: tomatoes; On: onion; Cu: cucumbers; Lt: Lettuce; Satisfactory: *S*; acceptable: *Ac*; Unsatisfactory: *Un*; Corrupt: *C*.

The presence of bacteria with high prevalence and loads in this study could be due to these factors and practices observed during the preparation in collective restoration and which are susceptible to favor this contamination. The raw mixed vegetable salad samples analyzed contained *Enterobacteriaceae*, *E. coli* and *Salmonellaspp* with prevalence and variable average loads. *Enterobacteriaceae* were found in all samples analyzed with a concentration of 4.9 ± 1.1 $\log_{10}$ CFU/g. The result obtained is in agreement with that of Mohammed and Bahreini [23] who obtained 100% prevalence in Iran, but different from those of Nguz *et al.* [24], who obtained a prevalence of 73.3%. The presence of enterobacteria in raw vegetable salads can be explained by the fact that they are very widespread and widely distributed in the environment via soil, water, intestines of animals and humans, and vegetables. Some enterobacteria are naturally found among the flora associated with growing vegetables [25]. For this reason, the microbiological criteriae for determining the microbiological quality of food are not applicable to fruit and vegetable salads or fresh foods that contain raw fruits and vegetables. According to the health protection agency [26], enterobacteriaare used to assess the general state of hygiene of food products. In thermally untreated products, such as fruits and vegetables, processing methods can reduce the initial load of often very high contamination [26]. Therefore, always having a high load of these types of bacteria in vegetables ready for consumption in the final stage means inadequate treatment [27]. Samples taken during the day had a significantly higher enterobacterial load (5.1 ± 1.1 $\log_{10}$ CFU/g) than the samples collected overnight (4.7 ± 1.04 $\log_{10}$ CFU/g). This difference could be

explained by the fact that during the day, raw vegetable salads are used much more as accompaniment of grilled fish. This could be due to cross-contamination during cutting, since the utensils are being used to cut both vegetables and fish. Studies also confirm that fresh fish contain enterobacteria with prevalence up to 100% and loads of 5.3 $\log_{10}$ CFU cm^2 [28] [29].

The prevalence of *E. coli* in our study was 77.8% with an average concentration of 1.89 ± 1.29 $\log_{10}$ CFU/g and 52.3% of the samples that exceeded the recommended limits. These results are contrary to those of Soncy *et al.* [30] in Togo and Antwi-Agyei *et al.* (2015 [31]) in Ghana, which obtained much higher loads of 2.5×10^3 CFU/g (3.4 $\log_{10}$ CFU/g) and 4.23 $\log_{10}$ CFU/g, respectively, with a prevalence of 22.8% and 98%. Similarly, Barrada *et al.* [32] in Morocco and Amposah *et al.* [33]) in Ghana had obtained respectively 99.3% and 100% raw vegetable salads unsatisfactory microbiological quality. On the other hand, Pesewu *et al.* [34] in Ghana obtained a load close to our results (1.89 ± 1.29 $\log_{10}$ CFU/g), which is 1.6 $\log_{10}$ CFU/g, but with a lower prevalence (35%). In Iran, Mohammad *et al.* [23] and Avazpour *et al.* [35] obtained 27.8% and 69% prevalence respectively with 6.3% and 69% of samples of unsatisfactory microbiological quality.

In our study, *Salmonella* was detected in 2.6% of the samples. This prevalence is lower than those obtained in India [36] and Harare [37] of 5.8% and 14% respectively. However, in Lomé [9], Uganda [38], Iran [35] and Kumasi [10] no *Salmonella* was detected in the salad samples. All samples analyzed containing *Salmonella* are unfit for human consumption and pose a risk to consumer health.

The prevalence, average loads and number of samples of unsatisfactory microbiological quality compared to *E. coli* and *Salmonella* were significantly higher in salads containing onion, tomato, cucumber and lettuce and in salads collected at night. This could be explained by the number and nature of the vegetables making up the salad and also by the types of meals that are used in accompanying these salads at night. Lettuce, because of its irregular structure, sometimes has a prevalence and average load in larger microorganisms [10]. At night, vegetable salads are much more used as an accompaniment of grilled or braised chicken. Cross-contamination by contact of vegetable salads with fresh chicken or utensils that have been in contact with this food as observed in the survey could be the basis of this situation. The conditions of sale, including personal hygiene, could also be involved. Work carried out by Bony *et al.* [39] and Koffi *et al.* [40] have shown that carcasses and fresh products from chickens on the markets of Abidjan are contaminated with strains of *E. coli* and *Salmonella*. From one commune to another, there was no significant difference in the prevalence, mean concentration and level of samples of unsatisfactory micro-biological quality compared to *E. coli* and *Salmonellaspp* ($P > 0.05$). This result suggests in a general way that practices among sellers are the same from one commune to another.

Handling practices in the food service establishment from point of service

preparation should therefore be a critical concern for food workers and consumers since they can provide great opportunities for cross-contamination of microbes from raw products to ready-to-eat foods [10]. According Amoah *et al.* [17], unsanitary handling practices after the fields and in the marketing, do not increase the levels of initial contamination; however, the preparation of these foods before consumption in collective catering is the critical stage at which it is absolutely necessary to minimize the microbial load. At this stage, because these foods are consumed without further heat treatment, they require good handling conditions and the use of effective decontamination methods to minimize contamination and thus preserve the health of consumers.

5. Conclusion

This study shows that raw mixed vegetable salads consumed in collective catering in Abidjan are contaminated with *E. coli* and *Salmonella*. In some cases, average loads are above the limits recommended by WHO and ICMSF to ensure consumer health. Since raw mixed vegetable salads are consumed directly without any treatment, emphasis should be placed on the proper handling conditions of these. Effective decontamination methods such as Sodium hypochlorite should also be used to minimize any form of contamination and to preserve the health of consumers.

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